CHAPTER 3

Criteria Pollutants - Metropolitan Area Trends

http://www.epa.gov/oar/aqtrnd97/chapter3.pdf

This chapter presents status and trends in criteria pollutants for Metropolitan Statistical Areas (MSAs) in the United States. The MSA trends and status give a local picture of air pollution and can reveal regional patterns of trends. Such information can allow one to gauge the air pollution situation where they live although not all areas in the country are in MSAs and not all MSAs are included here. A complete list of MSAs and their boundaries can be found in the Statistical Abstract of the United States.[1] The status and trends of metropolitan areas are based on four tables found in Appendix A (A-13 through A-16). Table A-13 gives the 1997 peak statistics for all MSAs, providing the status of the most recent year. Ten-year trends are shown for the 251 MSAs having data that meet the trends criteria explained in Appendix B. Table A-14 lists these MSAs and reports criteria pollutant trends as "upward" or "downward," or "not significant." These categories are based on a statistical test, known as the Theil test, which is described later in this chapter. The results of these tests are displayed in Figures 3-1 through 3-9 as maps showing upward, downward or non-significant trends. Another way to assess trends in MSAs is to examine Pollutant Standards Index (PSI) values.[2,3] The PSI is used to combine daily information on one or more criteria pollutants into an easily understood format, which can then be presented to the public in a timely manner. Tables A-15 and A-16 list the number of days with PSI values greater than 100 (unhealthy for sensitive groups) for the nation's 94 largest metropolitan areas (population greater than 500,000). Table A-15 lists PSI values based on all pollutants, while Table A-16 lists PSI values based on ozone alone. For the 10-year period, the PSI calculated for ozone is based on the revised standard discussed in Chapter 2. The tables listing PSI data from previous reports may not agree with the tables in this report because of the new way to calculate the PSI for ozone.

Not every MSA appears in these tables because of the availability of data or the size of the MSA. There are MSAs with no ongoing monitoring because they are not believed to have pollution problems. The same is true for certain combinations of MSAs and pollutants. There are also MSAs with so little information that the criteria for trends analysis are not met (see Appendix B). Finally, there are MSAs that do not meet the population criteria for tables A-15 and A-16 and, therefore, are not included.

STATUS: 1997

The air quality status for MSAs can be found in Table A-13 (for related information, see Table A-12, peak concentrations for all counties with monitors that reported to the Aerometric Information Retrival System (AIRS) database). Table A-13 lists peak statistics for all criteria pollutants measured in an MSA. Since certain areas are not considered to have a problem with all criteria pollutants, all criteria pollutants are not measured in all MSAs and, therefore, are designated as "ND" (no data) for those pollutants. Examining Table A-13 shows that 129 areas had peak concentrations from at least one criteria pollutant exceeding standard levels. The number of areas is dramatically increased over the count from 1996 data (45 areas). The increase can be attributed to the change from the pre-existing ozone and particulate matter (PM) National Ambient Air Quality Standards (NAAQS) to the revised ozone and PM NAAQS and levels of the revised ozone and PM standards discussed in Chapter 2, rather than changes in ambient concentrations. These 129 areas represent 53 percent of the U.S. population. Similarly, there were 6 areas representing 8 percent of the population that had peak statistics that exceeded two or more standards. Only two areas, (Philadelphia, PA and St. Louis, MO) representing 3 percent of the U.S. population, had peak statistics from three pollutants that exceeded the respective standards. High values for two pollutants, PM_{10} and lead, are due to localized industrial sources in both of these MSAs. There were no areas, however, that violated four or more standards. In fact, 1997 was the sixth year in a row that there were no violations of the nitrogen dioxide (NO_2) standards in the United States.

TRENDS ANALYSIS

Table A-14 displays air quality trends for MSAs.[4] The data in this table are average statistics of pollutant concentrations from the subset of ambient monitoring sites that meet the trends criteria explained in Appendix B. A total of 251 MSAs have at least one monitoring site that meet these criteria. As stated previously, not all pollutants are measured in every MSA.

From 1988 to 1997, statistics based on the NAAQS were calculated for each site and pollutant with available data. Spatial averages were obtained for each of the 251 MSAs by averaging these statistics across all sites in an MSA. This process resulted in one value per MSA per year for each pollutant. Although there are seasonal aspects of certain pollutants and, therefore, seasonality in monitoring intensity for different MSAs, the averages for every MSA and year provide a consistent value with which to assess trends.

Since air pollution levels are affected by variations in meteorology, emissions, and day-to-day activities of populations in MSAs, trends in air pollution levels are not always well defined. To assess upward or downward trends, a linear regression was applied to these data. An advantage of using the regression analysis is the ability to test whether or not the upward or downward trend is real (significant) or just a chance product of year-to-year variation (not significant). Since the underlying pollutant distributions do not meet the usual assumptions required for common least squares regression, the regression analysis was based upon a nonparametric method commonly referred to as the Theil test.[5,6,7] Because linear regression estimates the trend from changes during the entire 10-year period, it is possible to detect an upward or downward trend even when the concentration level of the first year equals the concentration level of the last year. Also, this method uses a median estimator which is not influenced by single extreme values.

Table 3-1 summarizes the trend analysis performed on the 251 MSAs. It shows that there were no upward trends in carbon monoxide (CO) and PM_{10} (annual mean) at any of the MSAs over the past decade. Of the 251 MSAs, 221 had downward trends in at least one of the criteria pollutants, and only 15 had upward trends. A closer look at these 15 MSAs reveals that most are well below the NAAQS for the respective pollutant, meaning that their upward trends are not immediately in danger of violating the NAAQS. The areas that were near or exceeding a NAAQS all involved 8-hour ozone with a significant upward trend. These results demonstrate significant improvements in urban air quality over the past decade.

Table 3-1. Summary of MSA 10-Year Trend Analyses, by Pollutant

		Total # MSAs	# MSAs Up	# MSAs Down	# MSAs with No Significant Change
CO	Second Max, 8-hour	142	0	102	40
Lead	Max Quarterly Mean	93	1	73	19
NO_2	Arithmetic Mean	92	4	51	37
Ozone	Second Daily Max, 1-hour	193	1	46	146
Ozone	Fourth Daily Max, 8-hour	193	4	32	157
PM_{10}	99th Percentile, 24-hour	207	0	159	48
PM_{10}	Weighted Annual Mean	207	4	78	125
SO_2	Arithmetic Mean	146	2	102	42
SO_2	Second Max, 24-hour	146	3	93	50

Figure 3-1. CO Trends in Metropolitan Statistical Areas, 1988–1997.

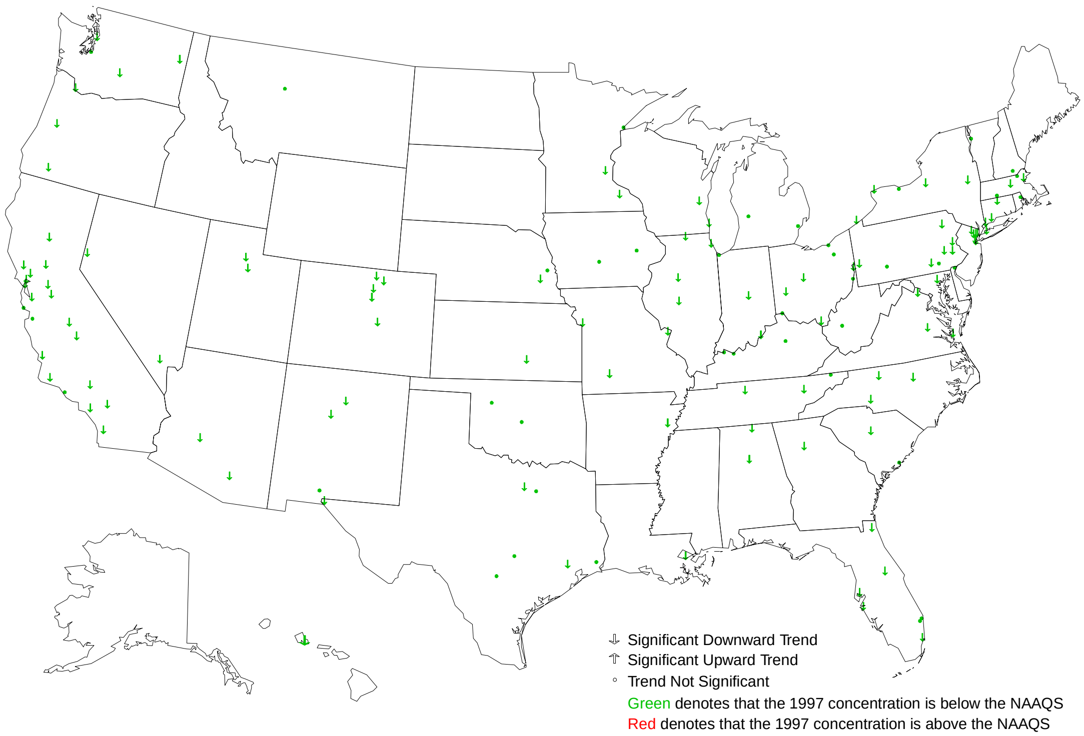


Figure 3-2. Pb Trends in Metropolitan Statistical Areas, 1988–1997.

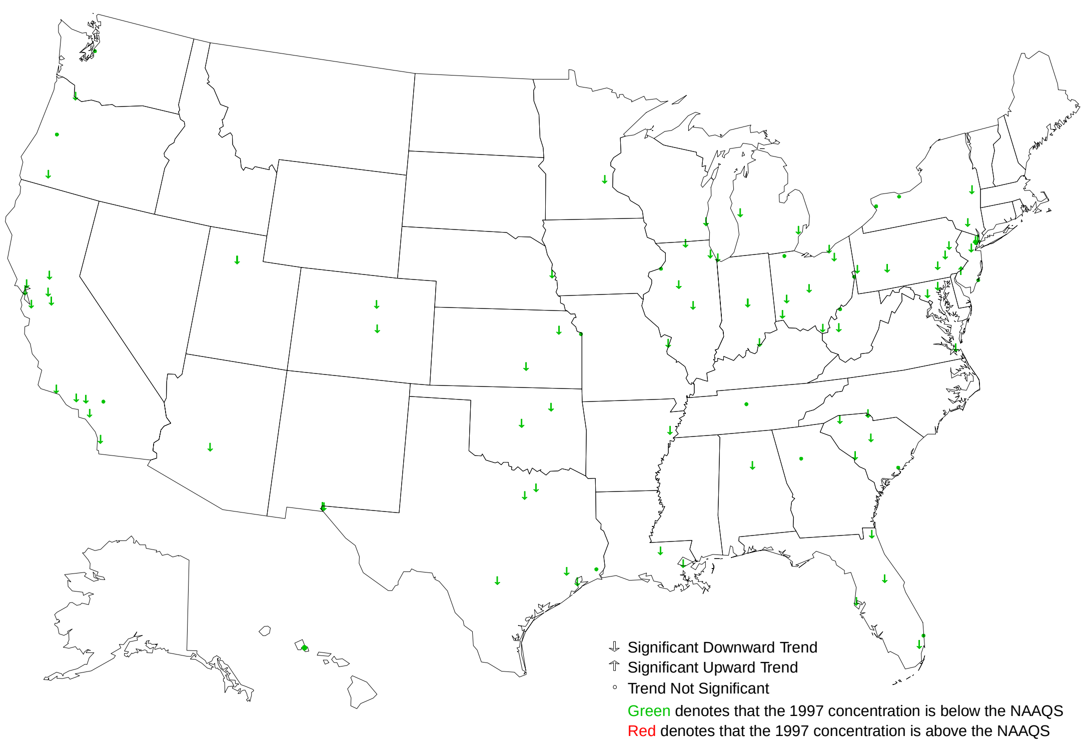


Figure 3-3. NO_2 Trends in Metropolitan Statistical Areas, 1988–1997.

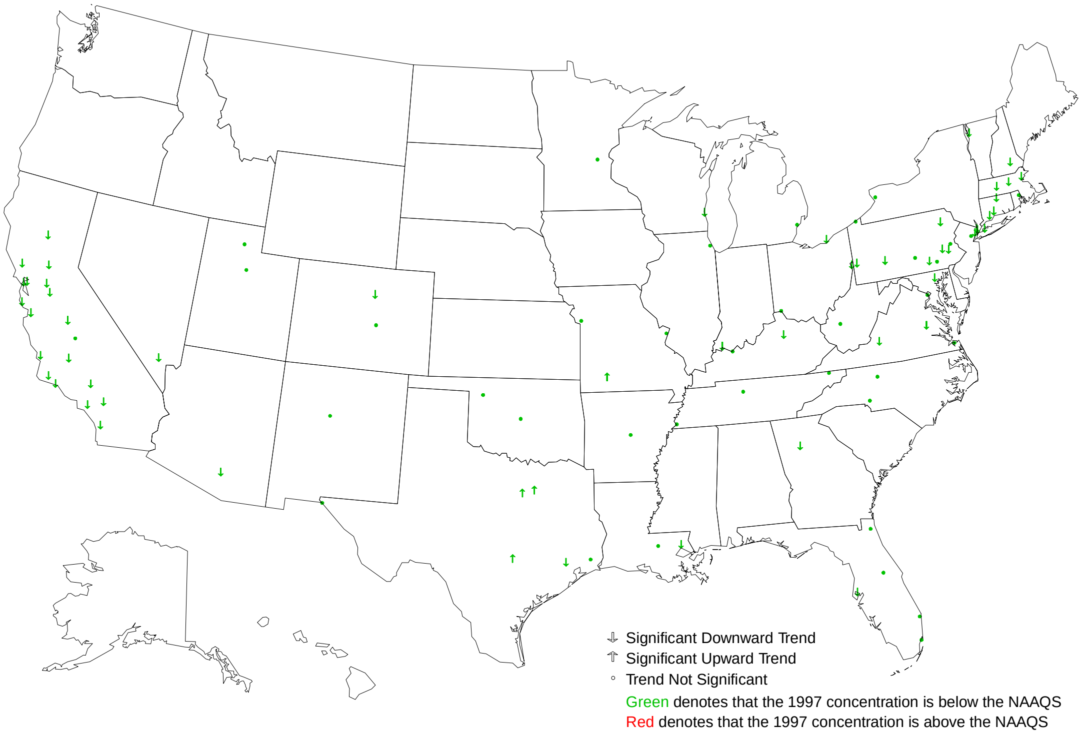


Figure 3-4. Ozone Trends in Metropolitan Statistical Areas (Fourth Max 8-hour), 1988–1997.

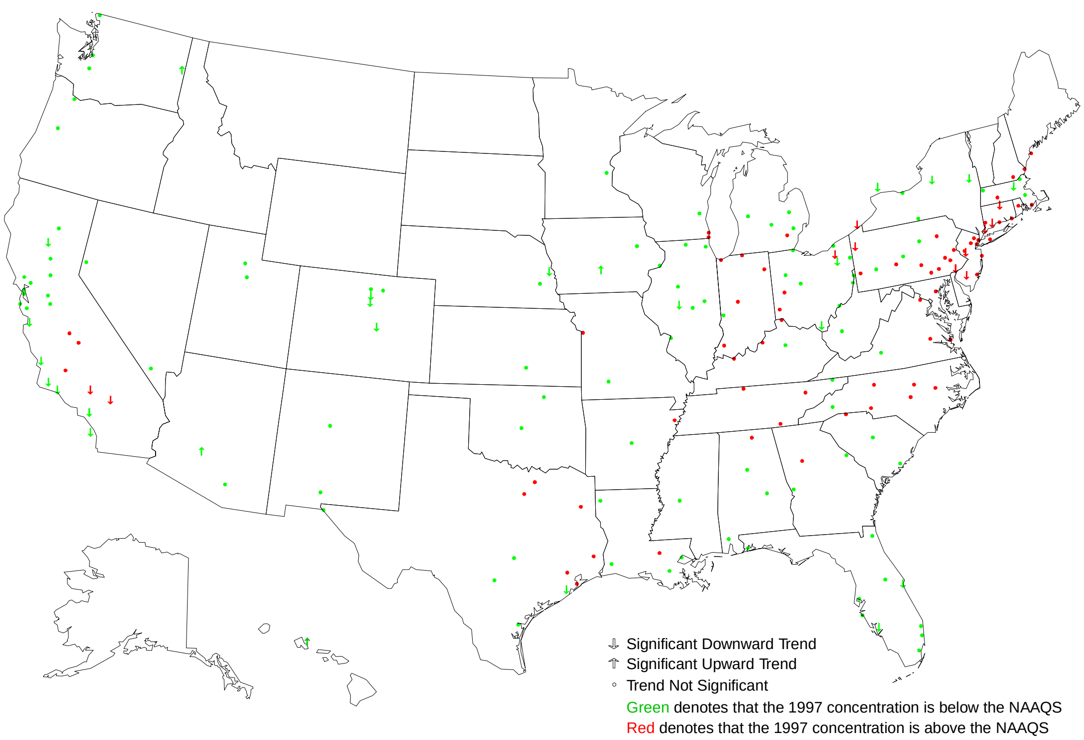


Figure 3-5. Ozone Trends in Metropolitan Statistical Areas (Second Daily Max 1-hour), 1988–1997.

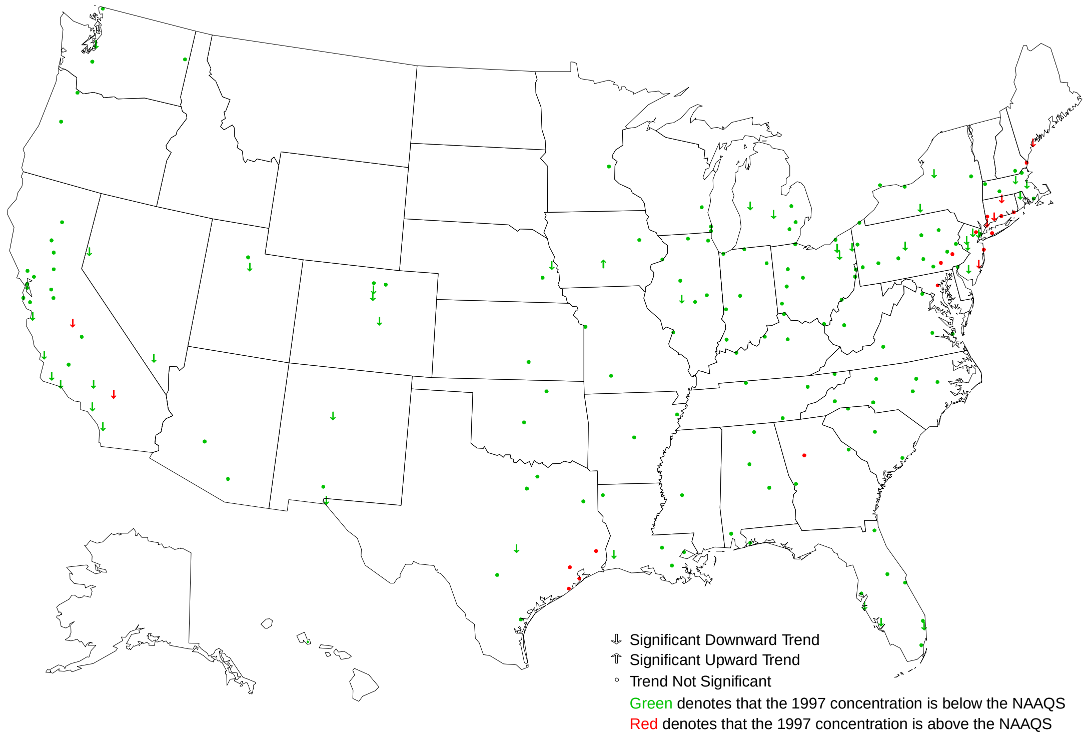
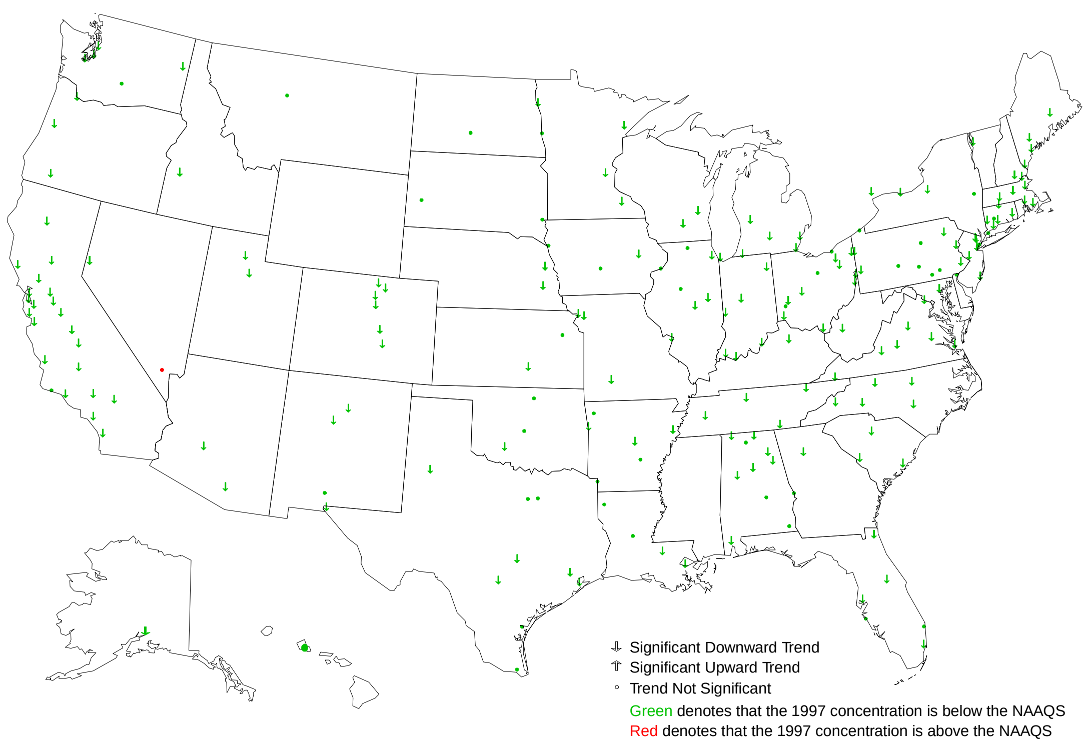


Figure 3-6. PM_{10} Trends in Metropolitan Statistical Areas (Weighted Annual Mean), 1988–1997.



Figures 3-1 through 3-9 summarize the results of the trends analysis geographically. This gives another general indicator of how air quality varies from one region to another. Figure 3-1 shows the geographic distribution of trends for CO. The figure shows that while most of the nation is experiencing a downward trend, there are small pockets where the trend is non-significant (Southern Pennsylvania to Kentucky and parts of Texas, Oklahoma, and New Mexico). Figure 3-2 shows that trends for lead (Pb) are down for almost all of the country. Figure 3-3 shows that trends for NO_2 are either down or non-significant with a small pocket of upward trends in Texas. Figures 3-4 and 3-5 show the ozone situation for MSAs throughout the country. Most MSAs have a non-significant trend with downward trends showing up in Southern California and some of the Northeast corridor. Figure 3-5, based on the 8-hour ozone standard, shows more areas with 1997 data above the level of the revised standard. Figures 3-6 and 3-7 show trends for the annual and the revised daily form of the PM_{10} standards. Figure 3-6 shows the PM_{10} weighted annual mean has mostly downward trends with the exception of areas in Pennsylvania and the northern plains states and a few other isolated MSAs. The daily form of the standard (Figure 3-7) shows non-significant trends from Pennsylvania in all directions except southwest, and from the northern plains south to all the plains states and into Arkansas and Louisiana. Figures 3-8 and 3-9 give a picture of the annual and daily SO_2 forms of the standard. A busy area from Illinois through New Jersey show downward trends, while many of these MSAs have non-significant trends for the daily form of the SO_2 standard.

The Pollutant Standards Index

PSI values are derived from pollutant concentrations. They are reported daily in all urban areas of the United States with populations exceeding 200,000. The PSI is reported as a value between zero and 500 or a descriptive word (e.g., "unhealthy") and is featured on local television or radio news programs and in newspapers.

Figure 3-7. PM_{10} Trends in Metropolitan Statistical Areas (99th Percentile), 1988–1997.

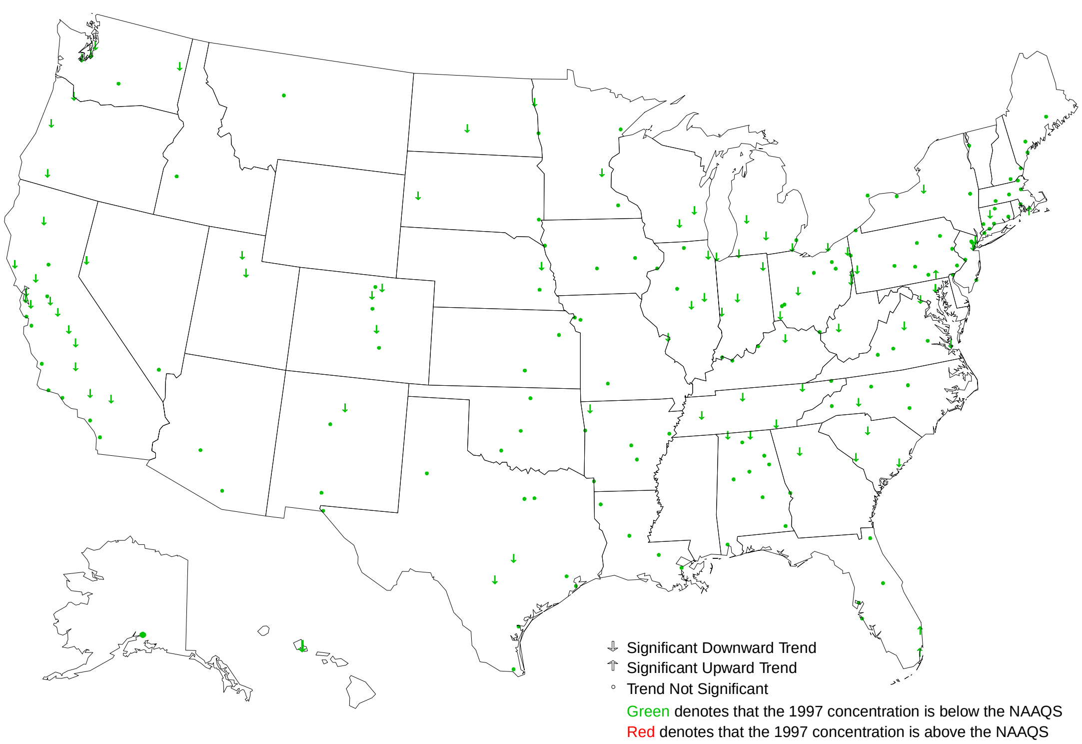


Figure 3-8. SO_2 Trends in Metropolitan Statistical Areas (Arithmetic Mean), 1988–1997.

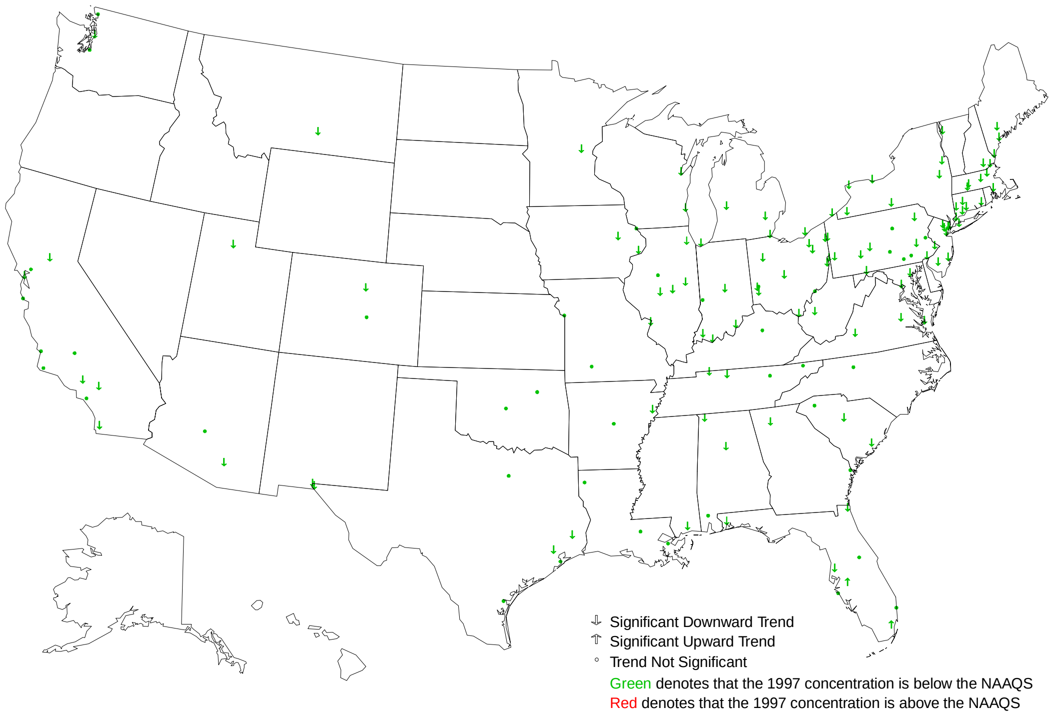
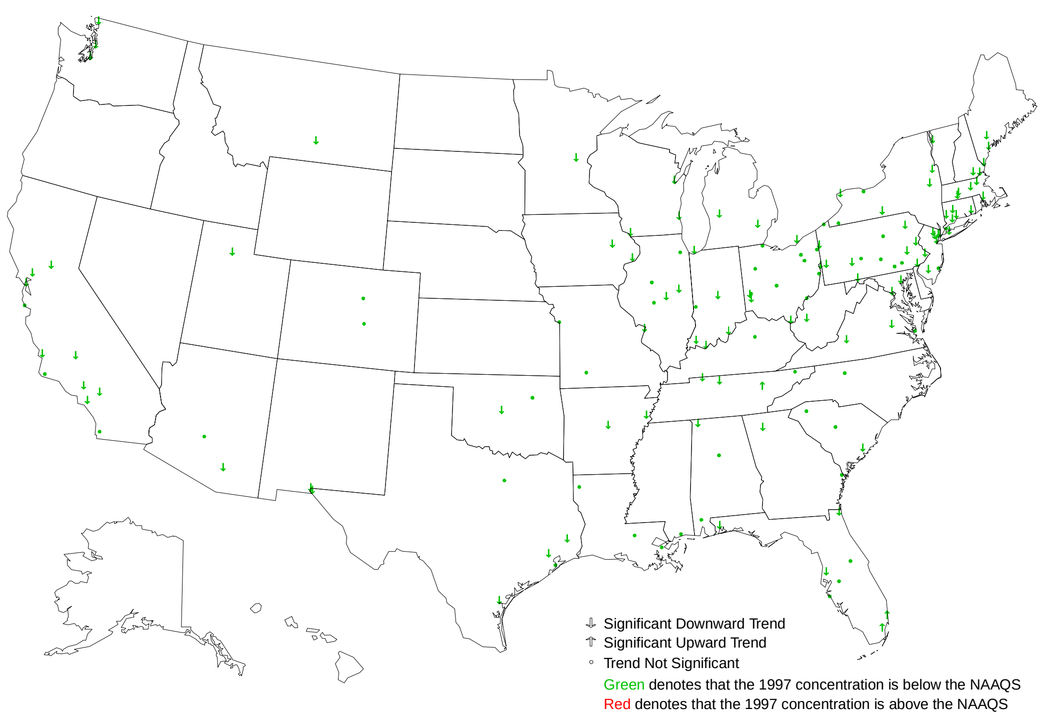


Figure 3-9. SO_2 Trends in Metropolitan Statistical Areas (Second Max 24-Hour), 1988–1997.



Based on their short-term NAAQS, Federal Episode Criteria,[8] and Significant Harm Levels,[9] the PSI is computed for PM_{10}, SO_2, CO, O_3, and NO_2. Lead is the only criteria pollutant not included in the index because it does not have a short-term NAAQS, a Federal Episode Criteria, or a Significant Harm Level. Since the PSI is a tool used to communicate pollution concerns to a wide audience, there are also colors linked to the general descriptors of air quality. The five PSI color categories and their respective health effects descriptors are listed in Table 3-2.

The PSI integrates information on criteria pollutant concentrations across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. For each of the criteria pollutants, concentrations are converted into an index value between zero and 500. The pollutant with the highest index value is reported as the PSI for that day. Therefore, the PSI does not take into account the possible adverse effects associated with combinations of pollutants (i.e., synergism).[2,3]

A PSI value of 100 corresponds to the standard established under the Clean Air Act (CAA). A PSI value greater than 100 indicates that at least one criteria pollutant (with the exception of NO_2) exceeded the level of the NAAQS, therefore designating air quality to be in the unhealthful range on that day. Relatively high PSI values activate public health warnings. For example, a PSI of 200 initiates a First Stage Alert at which time sensitive populations (e.g., the elderly and persons with respiratory illnesses) are advised to remain indoors and reduce physical activity. A PSI of 300 initiates a Second Stage Alert at which time the general public is advised to avoid outdoor activity.

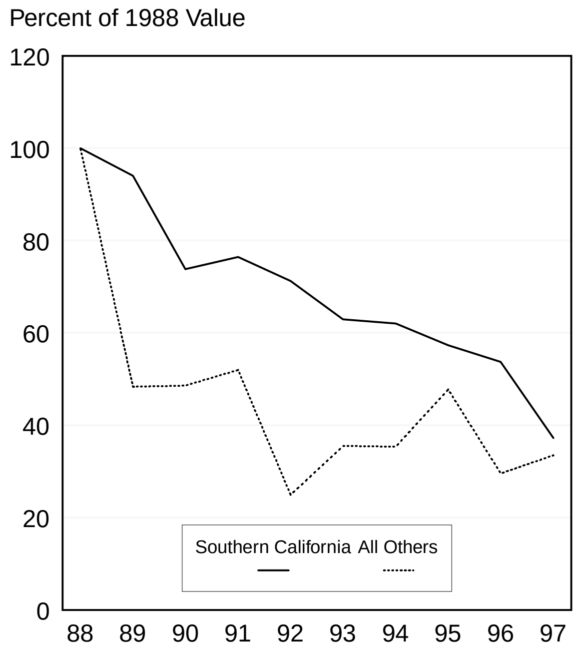
EPA is revising the PSI to reflect the revised ozone and PM NAAQS, which will incorporate the latest health effects information used to revise the standards. The analysis presented here uses a suggested revision for ozone that states were encouraged to use during the Summer of 1998. The PSI used for this analysis

Table 3-2. Pollutant Standards Index Values with Pollutant Concentration, Health Descriptors, and PSI Colors.

INDEX VALUE	AIR QUALITY LEVEL	POLLUTANT LEVELS PM-10 (24-hour) ug/m³	SO_2 (24-hour) ug/m³	CO (8-hour) ppm	O_3 (1-hour) ppm	NO_2 (1-hour) ppm	HEALTH EFFECT DESCRIPTOR	PSI COLORS
500	SIGNIFICANT HARM	600	2,620	50	0.6	2.0		
400	EMERGENCY	500	2,100	40	0.5	1.6	HAZARDOUS	RED
300	WARNING	420	1,600	30	0.4	1.2		
							VERY UNHEALTHFUL	ORANGE
200	ALERT	350	800	15	0.2	0.6		
							UNHEALTHFUL	YELLOW
100	NAAQS	150	365	9	0.12	a		
							MODERATE	GREEN
50	50% OF NAAQS	50	80[b]	4.5	0.06	a		
							GOOD	BLUE
0		0	0	0	0	a		

[a] No index values reported at concentration levels below those specified by "Alert Level" criteria.
[b] Annual primary NAAQS.

Figure 3-10. Number of days with PSI values > 100, as a percentage of 1988 value.



incorporates the level (0.08 ppm) and form (max 8-hour average) of the revised ozone standard for all 10 years. For this reason, Tables A-15 and A-16 may not agree with PSI tables in earlier reports for the same year.

SUMMARY OF PSI ANALYSES

Of the five criteria pollutants used to calculate the PSI, CO, O_3, PM_{10}, and SO_2 generally contribute to the PSI value. Nitrogen dioxide is rarely the highest pollutant measured because it does not have a short-term NAAQS and can only be included when concentrations exceed one of the Federal Episode Criteria or Significant Harm Levels. Ten-year PSI trends are based on daily maximum pollutant concentrations from the subset of ambient monitoring sites that meet the trends criteria in Appendix B.

Since a PSI value greater than 100 indicates that the level of the NAAQS for at least one criteria pollutant has been exceeded on a given day, the number of days with PSI values greater than 100 provides an indicator of air quality in urban areas. Figure 3-10 shows the trend in the number of days with PSI values greater than 100 summed across the nation's 94 largest metropolitan areas as a percentage of the 1988 value. Because of their magnitude, PSI totals for Los Angeles, CA, Riverside, CA, Bakersfield, CA, and San Diego, CA are shown separately as Southern California. Plotting these values as a percentage of 1988 values allows two trends of different magnitudes to be compared on the same graph. The long-term air quality improvement in urban areas is evident in this figure. Between 1988 and 1997, the total number of days with PSI values greater than 100 decreased 56 percent in Southern California and 66 percent in the remaining major cities across the United States. While five criteria pollutants can contribute to the PSI, the index is driven mostly by ozone. The unusual ozone year, 1988, can be seen in this figure by the large decrease between 1988 and 1989 for all the areas but Southern California. Southern California was less affected by the unusual meteorology experienced that year in most of the nation (see Chapter 2). In fact, Figure 3-10 shows how much year-to-year meteorology affects air pollution levels, since Southern California has less year-to-year variability in meteorology and a smoother trend.

PSI estimates depend on the number of pollutants monitored as well as the number of monitoring sites where data are collected. The more pollutants measured and sites that are available in an area, the better the estimate of the PSI for a given day. Ozone accounts for the majority of days with PSI values above 100, but is collected at only a small number of sites in each area. Table A-16 shows the number of days with PSI values greater than 100 that are attributed to ozone alone. Comparing Table A-15 and A-16, the number of days with a PSI above 100 are increasingly due to ozone. In fact, the percentage of days with a PSI above 100 due to ozone have increased from 92 percent in 1988, to 97 percent in 1997. The increase is even more dramatic when the unusual meteorology experienced in 1988 is recognized (the 1989 percentage was much lower, 82 percent). This increase reveals that ozone increasingly accounts for those days above the 100 level and reflects the success in achieving lower CO and PM_{10} concentrations. However, the typical one-in-six day sampling schedule for most PM_{10} sites limits the number of days that PM_{10} can factor into the PSI determination.

The PSI currently is undergoing revision to reflect the changes in the ozone and PM NAAQS. These revisions will be proposed in the Spring of 1998 and should be finalized by the end of 1998. Concurrently, the Federal Episode Criteria and Significant Harm Levels for ozone and PM are being revised to reflect the health effects data that motivated the revisions to the ozone and PM NAAQS.

REFERENCES AND NOTES

1. *Statistical Abstracts of the United States, 1997*, U.S. Department of Commerce, U.S. Bureau of the Census.

2. *Measuring Air Quality, The Pollutant Standards Index*, EPA-451/K-94-001, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1994.

3. *Code of Federal Regulations,* 40 CFR Part 58, Appendix G.

4. Note: Although the results are summarized in the report for comparison purposes, the intent of publishing Tables A-14 through A-16 is to present information on a localized basis, to be used on a localized basis (i.e., one MSA at a time). Therefore, no attempt was made to adjust the Type I error to a table-wide basis. All the tests for trends were conducted at the 5-percent significance level. No inference has been made from the tables as a whole.

5. T. Fitz-Simons and D. Mintz, "Assessing Environmental Trends with Nonparametric Regression in the SAS Data Step," American Statistical Association 1995 Winter Conference, Raleigh, NC, January, 1995.

6. Freas, W.P. and E.A. Sieurin, "A Nonparametric Calibration Procedure for Multi-Source Urban Air Pollution Dispersion Models," presented at the Fifth Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, Las Vegas, NV, November 1977.

7. M. Hollander and D.A. Wolfe, *Nonparametric Statistical Methods*, John Wiley and Sons, Inc., New York, NY, 1973.

8. *Code of Federal Regulations,* 40 CFR Part 51, Appendix L.

9. *Code of Federal Regulations,* 40 CFR Part 51, section 51.151.